Solar Powered Planes to NASA's Designs for 2025: Lightweight Aircraft Cabin Interiors of the Future

It's no surprise that, given the high cost of aviation fuel, the airline industry is extremely interested in materials that achieve significant weight reductions without compromising strength or durability. Airlines are continually pushing to compete on fuel efficiency not only for its sustainability perception, but also for substantial operating cost improvements. One way airlines are addressing fuel consumption is by designing lighter weight vehicle. Aircraft interior designs are therefore a hotly contested design feature as there are numerous weight improvements that can be made in this area of the aircraft.

Fuel Efficiency Constraints Demand Lighter Weight Aircraft Interiors

Perhaps one of biggest innovations in aircraft interior design is the use of composite materials. Because of the significantly lower weight of composite materials compared to conventional metals, these materials are translating into considerable costs savings in terms of fuel. As such, airlines are utilizing composites for everything from engine nacelles, seating and interior finishes, rudders, stabilizers, floor beams, elevators, and wing assemblies.

In general, composite components achieve similar strengths to conventional metals at a fraction of the weight. Compared to aluminum, carbon fiber composites are roughly half the weight, and one-quarter the weight of steel.[i]

As such, Airlines large and small are outfitting their fleets with composite materials. This is nowhere more true than in the race to create lightweight, fuel efficient planes that run on electricity or renewable energy. To achieve their high-flying goals, many manufacturers are employing hybrid and composite materials for their lightweight characteristics.

Volta Volaré GT4 made with composite material

Volta Volaré, a private aircraft manufacturer, for instance, recently launched a four-seat GT4 hybrid electric private aircraft which makes use of composite materials. Unbelievably, the entire aircraft is made of carbon fiber, including the aircraft cabin interior components.

This design was chosen over an aluminum aircraft component design because it reduces the weight of the aircraft by 50% to 60%.[ii] Similar weight reductions are being reported by many companies, including SABIC's Ultem which produces a carbon-fiber-filled polyetherimide (PEI) resin that can cut weight by 50%.[iii]

In talking to Aviation Today, Paul Peterson, CEO of Voltar Volaré, commented, "Our GT4 is constructed entirely of carbon fiber composite material so we have a great deal of experience with the adoption of alternative materials. ElectriPlast will be applied to current systems and component parts, which require shielding from electronic or magnetic emissions such as power electronics. This is an area that we see ElectriPlast technology playing a role in lightweighting by replacing traditional metals currently in use."

Likewise with a composite which has been used extensively in Airbus A380 aircrafts. Not only are these planes composed of 25% Fortron PPS, this material is used for the lumbar support in aircraft cabin seats, as well as the integrated folding table cover and seat edges. Based on a linear, semi-crystalline polyphenylene sulphide formulation, this material is composed of PPS films and fiber reinforcement that has increased stiffness and strength and is designed to meet the highest flame retardancy standards. They provide similar support to aluminum construction with half the weight.[iv]

A Look at the Future of Aircraft Designs

The airline industry has put a lot of stock into the promise of composite technology for the future of their aircraft design. In fact, both NASA and The Boeing Co. have included composites technology in their aircraft implementation plans into 2025. NASA's Environmentally Responsible Aviation (ERA) Project and the Boeing Research & Technology group are working to optimize composites for everything from hybrid aircraft wing/fuselage structures to larger transport aircraft that can carry more people on less fuel. This will ultimately have an impact on aircraft cabin design.[v]

Take, for instance, their blended wing structure design that has a box-like cabin, flatter walls, and hard angles. While this shape will provide greater fuel efficiency for the aircraft as a whole, it will require significantly stronger materials, especially for cabin walls. Since flat walled structures are subject to greater bending stresses

than cylindrical, barrel-shaped aircraft, fatigue-sensitive metals will no longer be viable for aircraft cabins.

The solution: a stitched skin, stringer-and-frame carbon fiber preform design. This PRSEUS (pultruded rod, stitched, efficient, unitized structure) is made with five integrated components cut and assembled from stacked fabric preform by Hexcel. Their AS4 carbon fiber preform for pressurized cabin walls design contains five main components (as described in *Composites World*):[vi]

- *Skin stack* — The skin stack forms the wall's flat surface structure.
- *Frame cap stack* — This stack is stitched in strips over the skin to provide a foundation for the frame stack (described later).
- *Stringer CL* — The stringer stack rests on this single-stack layer.
- *Stringer stack* — Boeing takes some of the AS4 stack material and wraps it around a pultruded carbon fiber rod. This rod-stiffened beam structure becomes the stringer, which Boeing stitches perpendicularly to the AS4 stack skin.
- *Frame stack* — The cored beam structure crosses the stringers perpendicularly. Here, the nine-ply multiaxial material is wrapped over an Evonik Foams (Magnolia, Ark.) ROHACELL foam core and notched, allowing it to nest atop the rod-stiffened stringer. The frame stack is stitched to the frame cap stack.

This is just one example of how carbon composites are being applied in the design of advanced aircraft interiors. We will likely continue to see composites used extensively in the airline industry as fuel costs rise and concerns about sustainability become more serious.

Solving Production Issues for Aircraft Cabin Interior Supplies

Yet before we can see a large-scale adoption of composites in the airline industry, we have to solve the current supply and production problems. Perhaps the most obvious reason for supply problems is that the average aircraft cabin will be modified at least three times during its lifespan (15 to 20 years), and that means even old planes are contributing to the squeeze on demand. Not only that, but because of the soaring production of commercial aircraft in recent months, a bottleneck for the production of interior components has developed.

But other factors are also in play. Airline mergers, increased demand for premium economy seats (designed with greater seat width and/or seat pitch), and fuel efficiency requirements are also driving the need for increased aircraft cabin retrofits. As a result, supplies are limited for everything from overhead bins to galleys, lavatories to aircraft seats, cabin management systems to in-flight entertainment and connectivity systems. Many question whether the industry can meet supply challenges.

To combat this problem, some manufacturers are simply working hard to increase production. Even some financially conservative airline suppliers are ramping up production. A supplier of aircraft cabin integration and retrofit programs for American Airlines, British Airways, Delta Air Lines, Lufthansa, United Airlines, Cathay Pacific, and Virgin Atlantic recently made the decision to double their number of employees over the last 18 months. This was done in order to meet demand in the commercial aircraft retrofit market.[vii]

Another production-improving trend has been toward standardizing aircraft interiors. Consider the recent Star Alliance's launch of the Star Plus seat. Designed with the same architecture, the seat can be customized by each airline with individual colours, fabrics, and in-flight entertainment systems to allow for brand identity and differentiation. But by standardising for the upcoming 440,000 economy class seats that will need to be produced (at a value of over USD $1 billion), the Star Alliance airlines (including Air Canada, Lufthansa, Scandinavian Airlines, Thai Airways, and United Airlines, to name a few) together can save a lot of money.[viii]

Yet several factors combine to complicate the situation. While standardization may well help alleviate some of the bottlenecking expected in the coming months and years, some airlines are more interested in differentiating their cabins. This increases the risk as it creates a more diverse production standard and therefore competing interests.

Most importantly, because manufacturers don't get paid until the aircraft goes into service, it is risky business to invest in infrastructure in order to ramp up production. But if they do not, the increased demand placed on the industry, especially with the increased orders for Airbus and Boeing aircraft such as the A320s, 737s, and A350s, will outstrip their current production capacity.

The Outlook for Aircraft Interior Improvements is Conservatively Positive

Clearly there are some kinks to work out in the aircraft interior market, especially given the production and supply challenges currently being experienced. Yet with the diversity in materials offerings and the drive to see fuel efficiency improvements, no doubt the industry will find its bearings and determine the best path forward. With any luck, the industry will experience a significant improvement in energy savings and materials sustainability over the long haul.

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